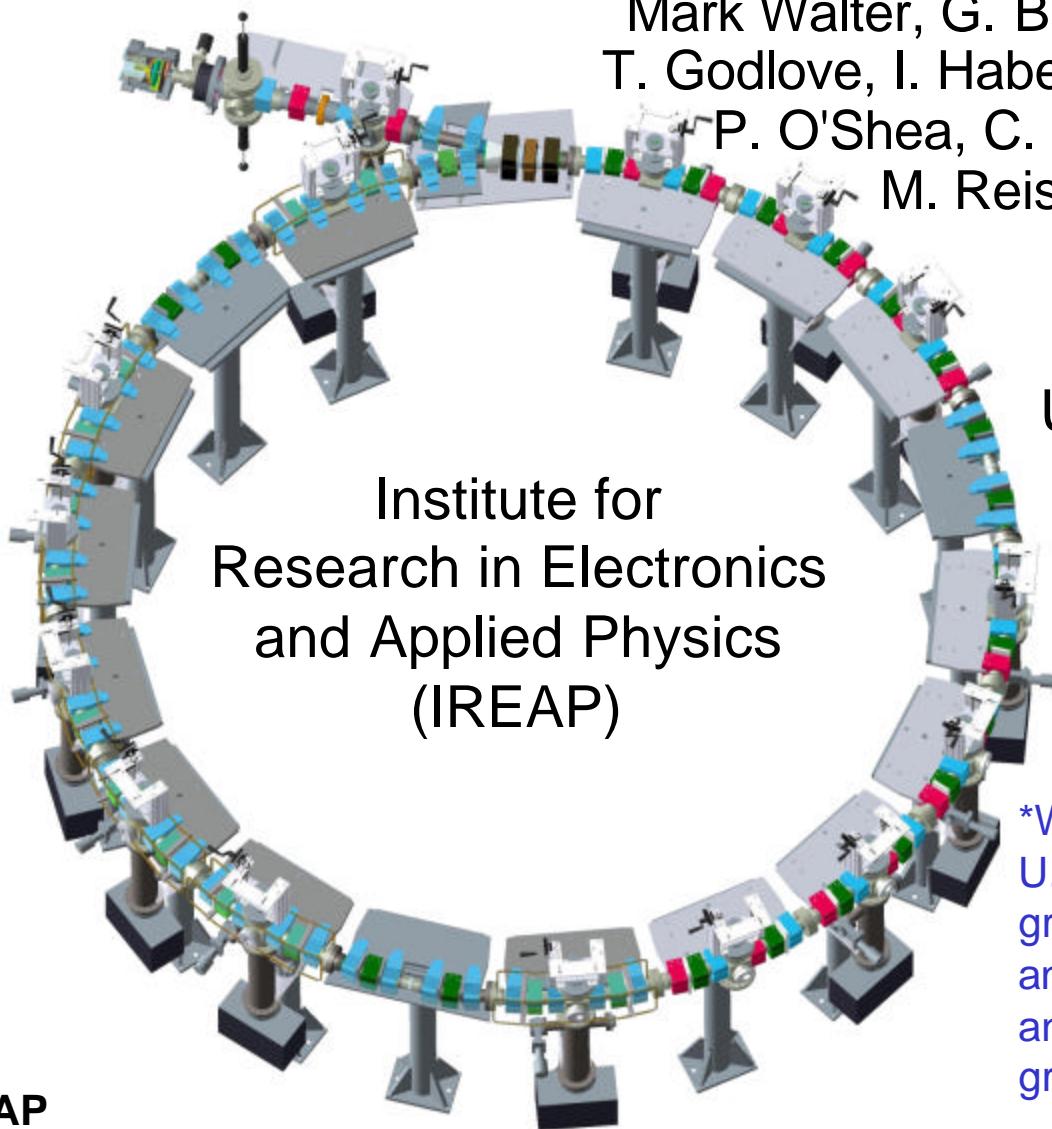




# Beam Control and Steering in the University of Maryland Electron Ring (UMER)\*



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Research in Electronics  
and Applied Physics  
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# The UMER Team

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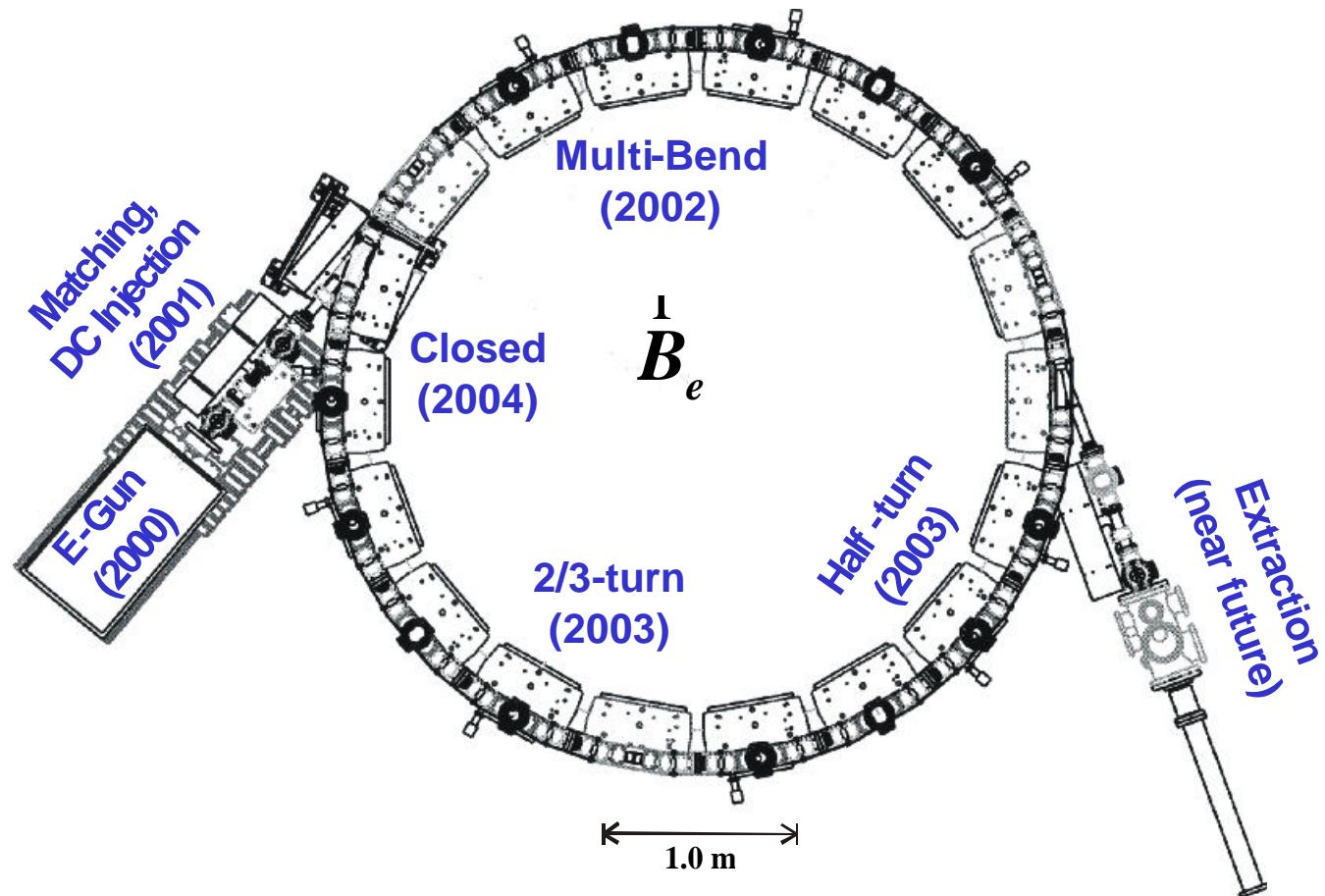


# Outline

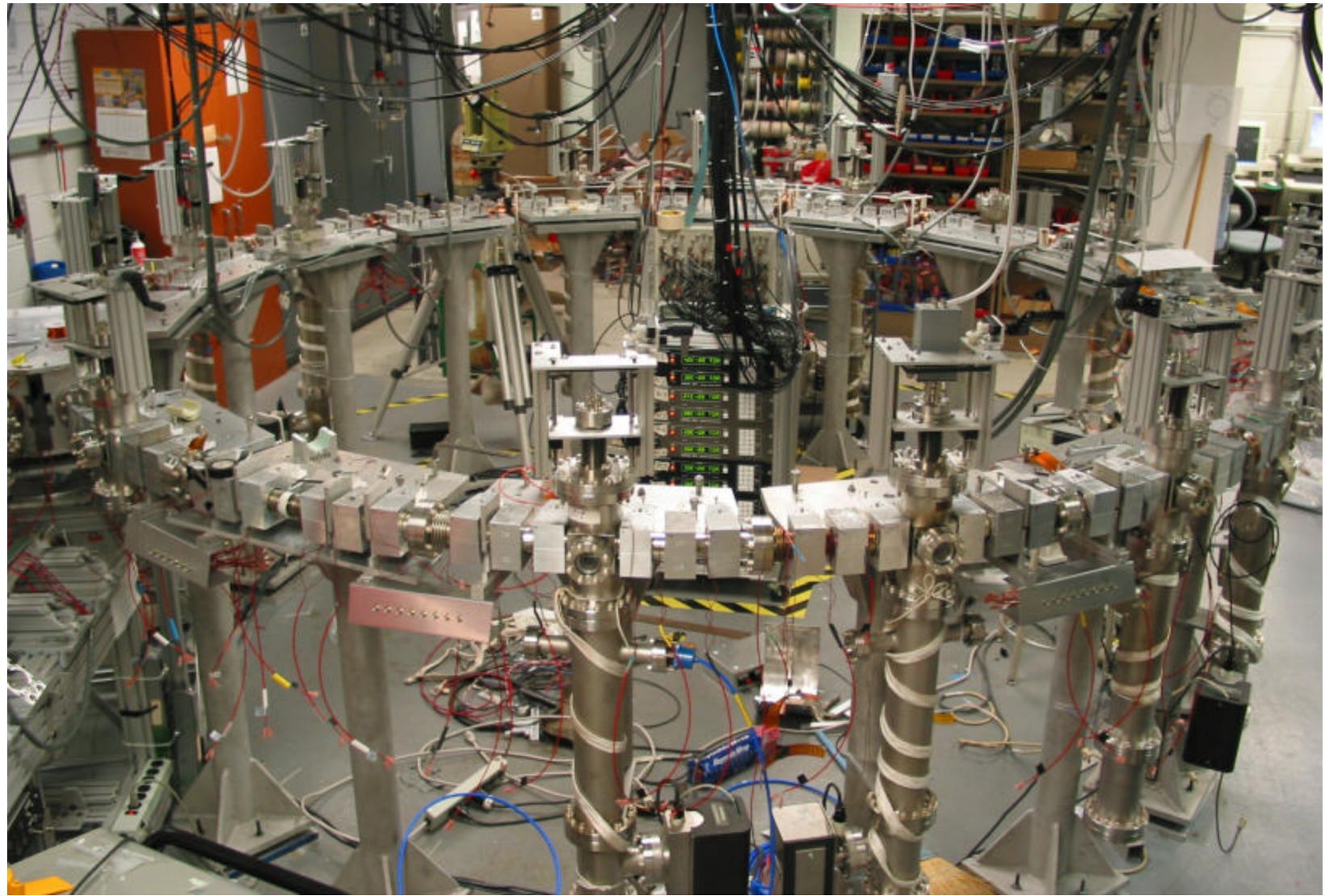
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- Overview of UMER
- Injection Line Steering
- Injection Y Steering
- Ring Steering
- Results & Conclusions

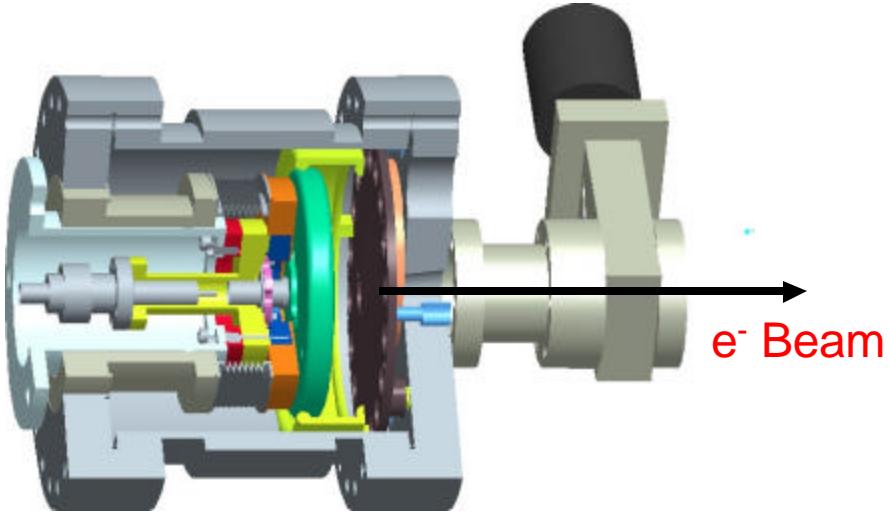
# Experimental Setup



# UMER (10/04)



# Electron Gun / Beam Parameters



Energy:	£ 10 keV, b=0.2
Current:	£ 100 mA
Emittance*:	£ 3.0 mm
*norm., rms	
Lattice period:	0.32 m
Undepr. $l_o$ :	> 1.5 m
Av. beam radius, $a$ :	£ 10 mm
Pulse Length:	50-100 ns
Lap time:	197 ns

# UMER is designed for **SCALED EXPERIMENTS** using **LOW ENERGY, HIGH CURRENT** electron beams.

Existing rings



Emittance  
Dominated

Space-charge  
Dominated

**Plasma  
Oscillations  
Curve**

$$\frac{n_p}{n_0} = \sqrt{2c}$$

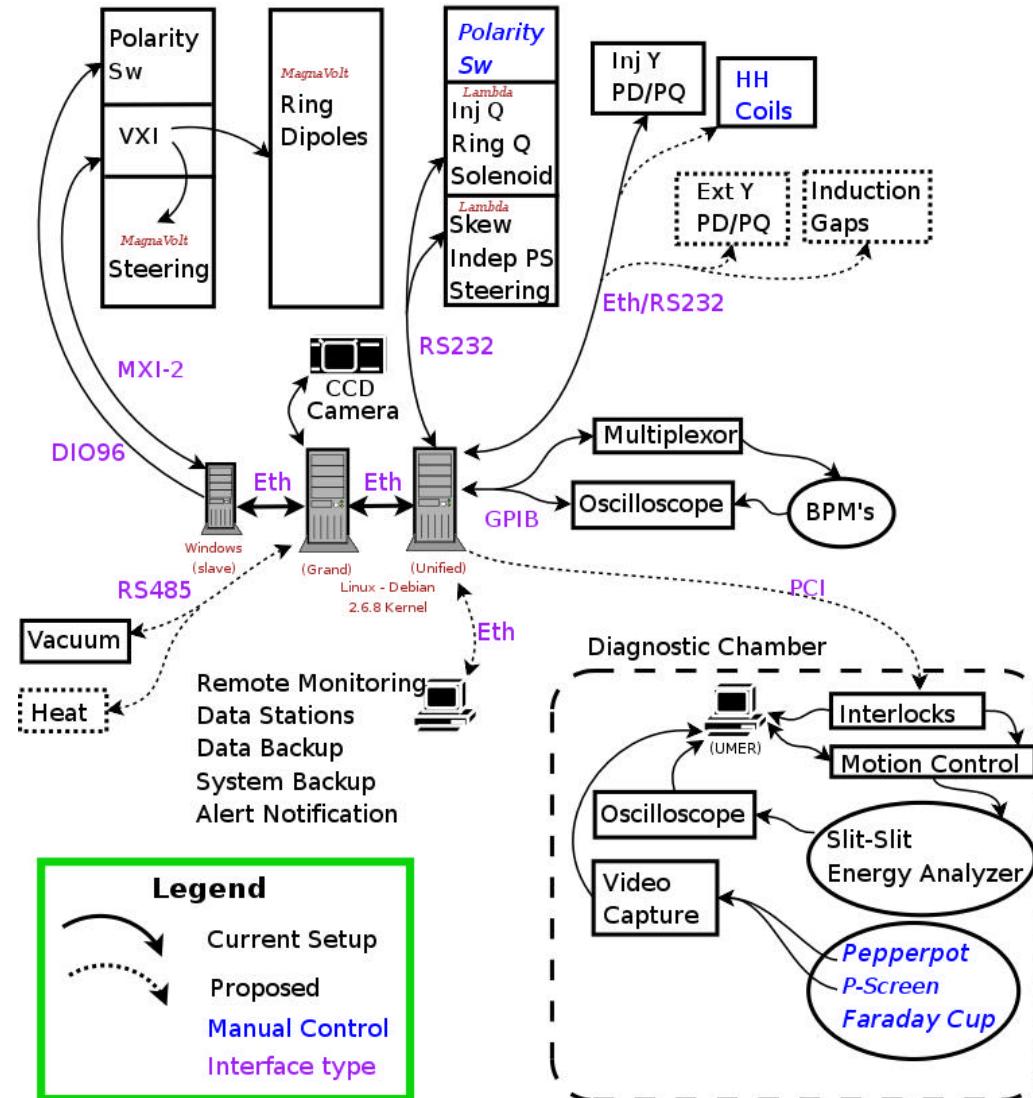
**Betatron  
Oscillations  
Curve**

$$\frac{n}{n_0} = \sqrt{1 - c}$$

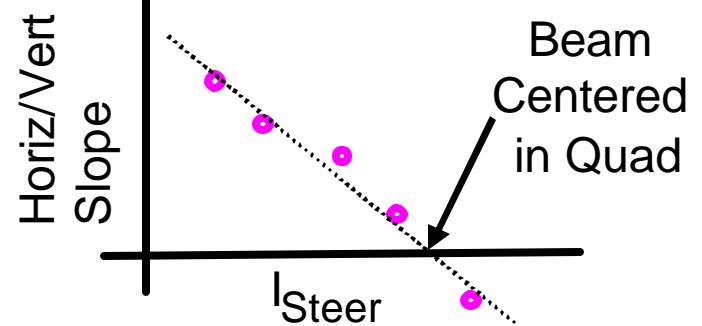
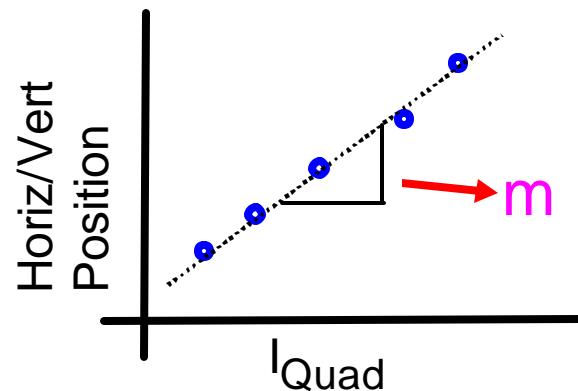
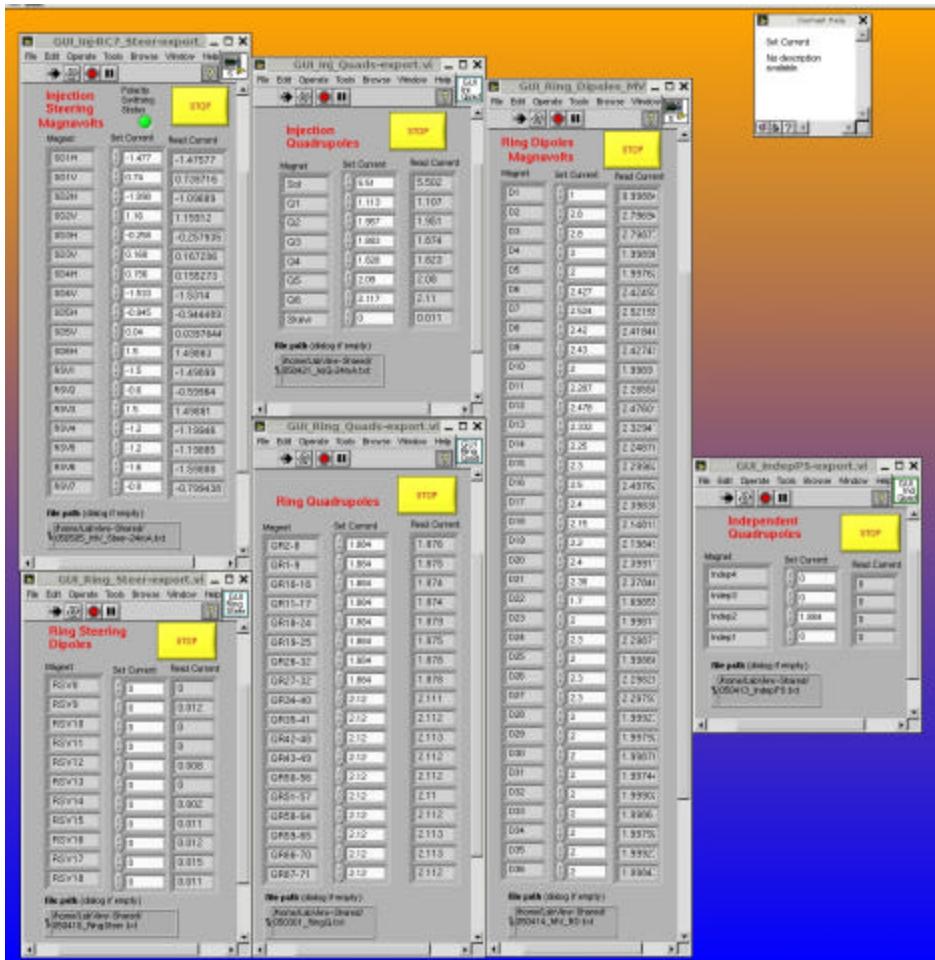
Intensity Parameter,  $c = \frac{K}{k_0^2 a^2}$

where  $K$ =gen. perveance  
and  $k_0 = \sigma_0 / s$

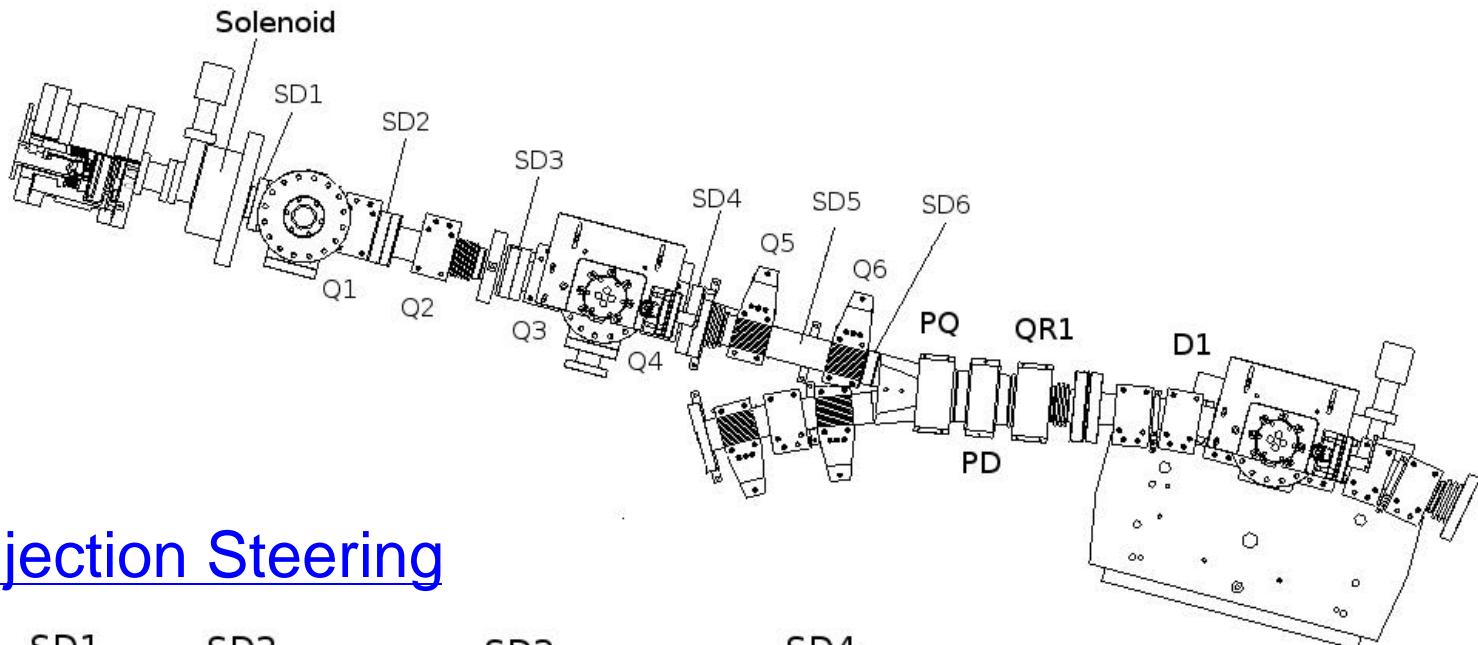
# UMER Control Schematic



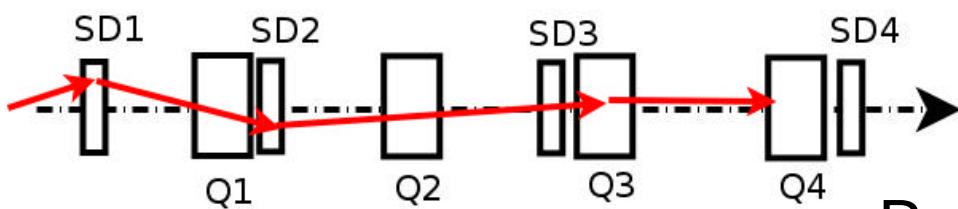
# Control Interface - LabView



# Matching/Injection Line



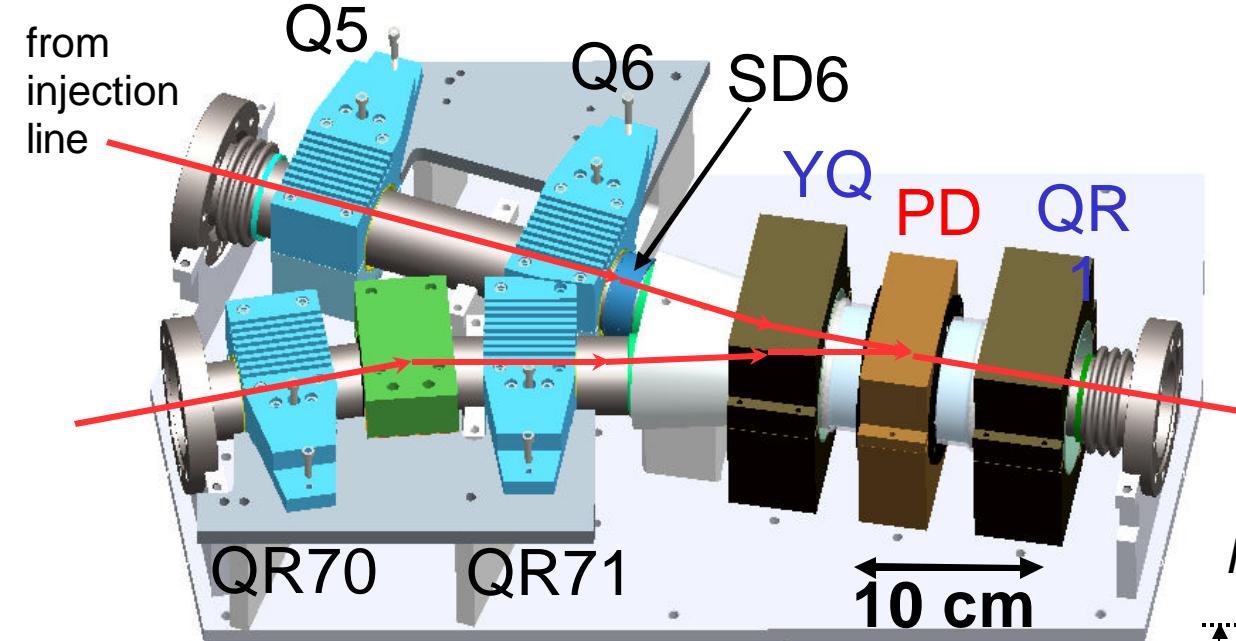
## Injection Steering



Coarse      Ignore Q1  
                  SD1 to Q2  
                  SD2 to Q3  
                  SD3...

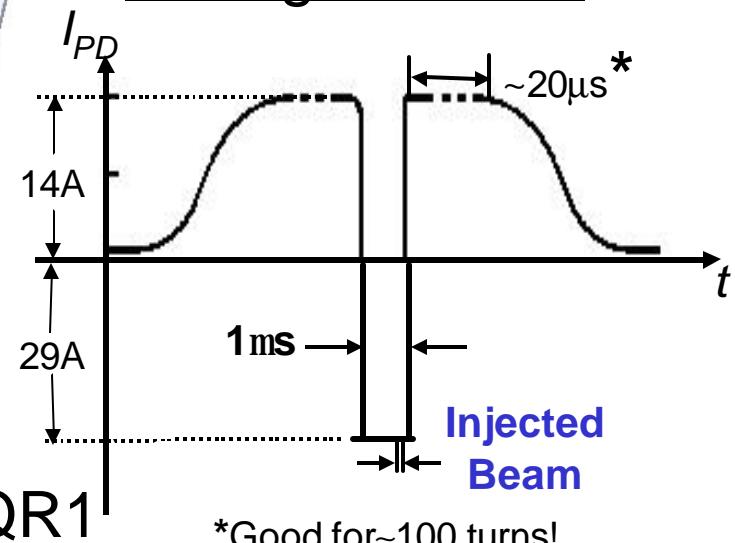
Refined  
Measure Response Matrix  
Invert matrix with SVD

# Pulsed Injector Y-Section



Black: DC  
Blue: Quasi-DC  
PD: Pulsed

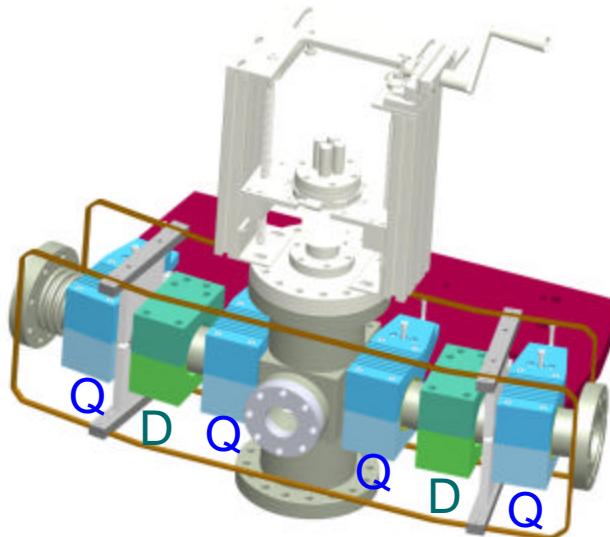
## Timing Scheme:



## Steering

- ★ SD6 to YQ
- ★ SD5 help – off center Q6
- ★ Timing Sensitivity
- ★ Digital control of YQ, PD, and QR1

# Ring Chamber with BPM, Phosphor Screen, OTR

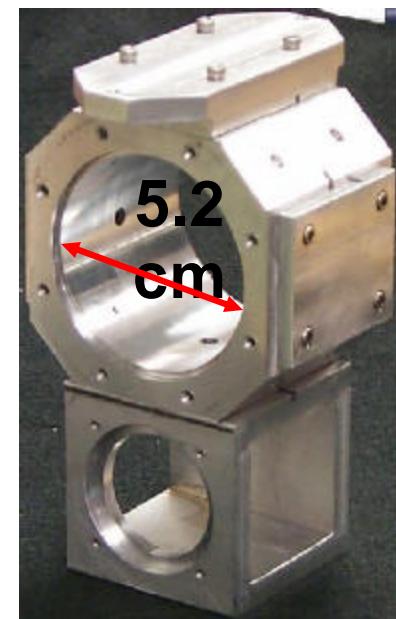


UMER Ring Section

14 BPM/Phosphor Screen  
(every 64 cm around ring)

Beam  
Position  
Monitor

0.1-0.4 mm, spatial res.  
2 ns, temporal res.



# Ring Steering

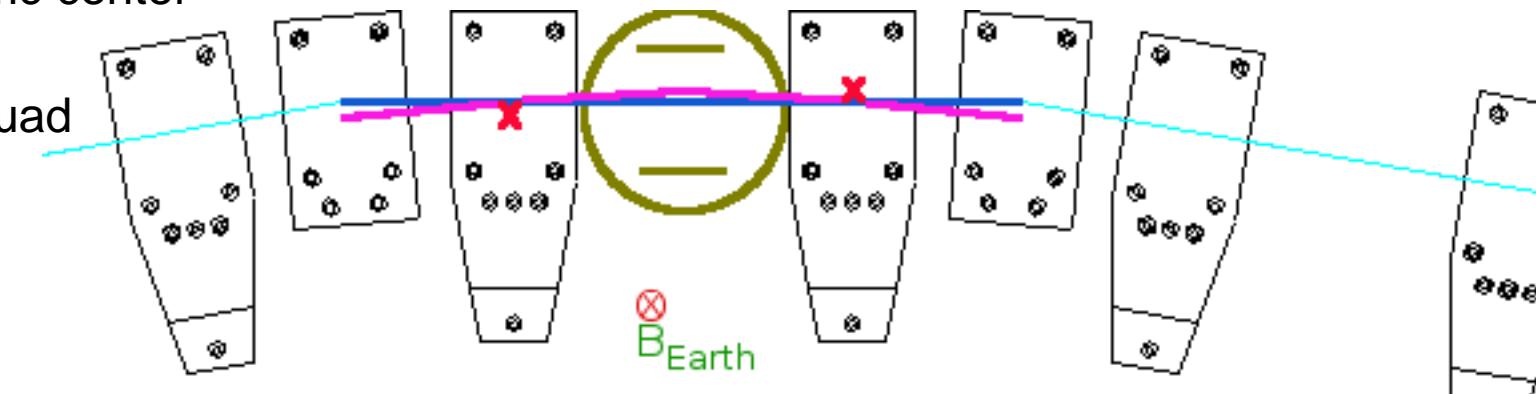
## Coarse Steering

Magnetic centers, Add Earth's field  $\rightarrow$  Slanted Trajectory and offset at dipole  
 $\sim 1\text{mm}$  offset

Aim for geometric center

Calibration of  
offset in quad

Offset in BPM



## Refined Steering

### Singular Value Decomposition

36 Ring Dipoles

2 Horiz kickers

18 Vert Kickers

+17 HHC

Response  
Matrix

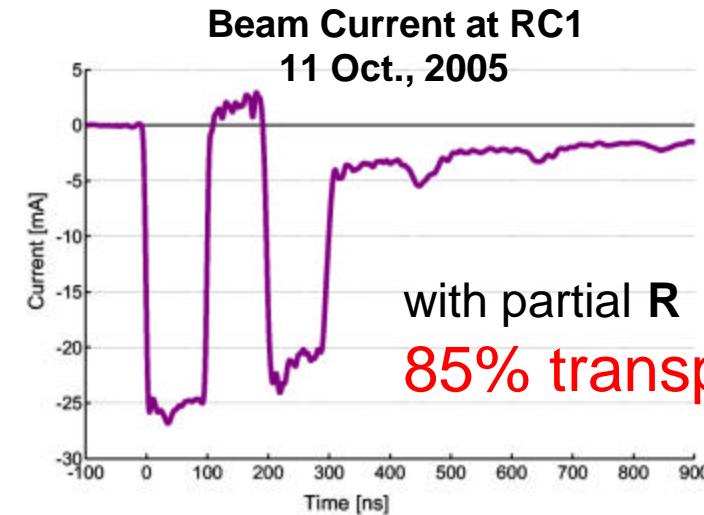
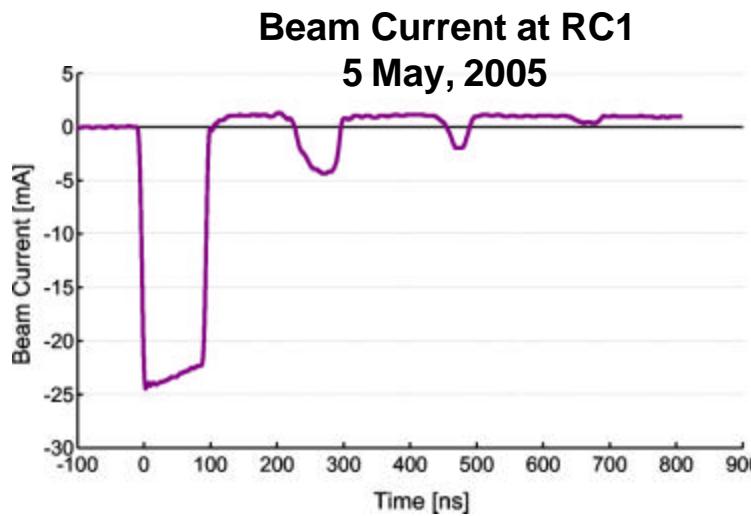
$$\mathbf{R} = [73 \times 71(\text{Quads})]$$

$$\mathbf{R}^{-1} = \text{SVD}(\mathbf{R})$$

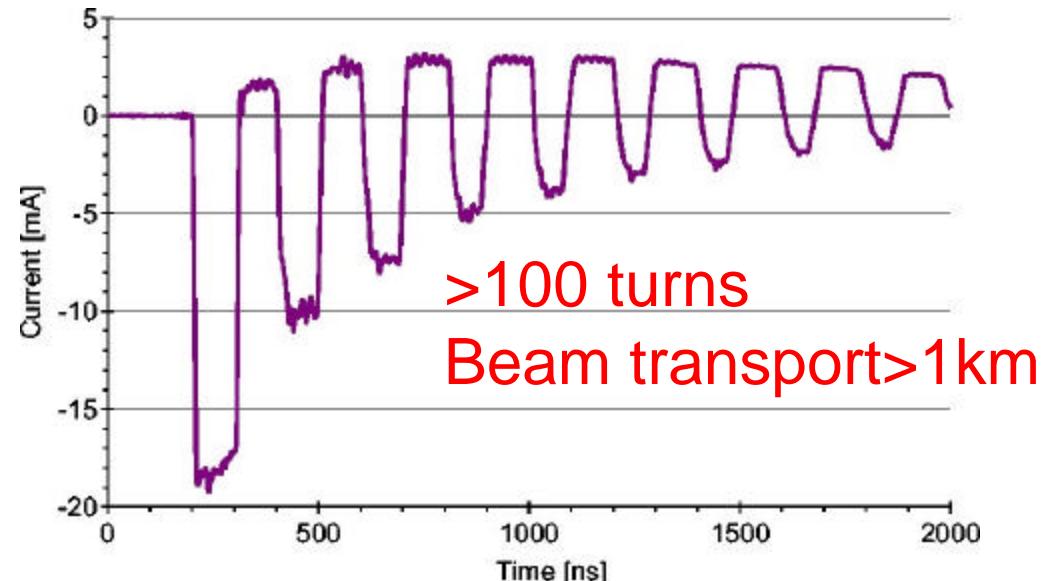
# Multi-turn Operation SVD Steering

Before and

After Partial R Construction



After Initial  
Optimization of  
Injection Y





## Summary/Conclusions

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- Improvements to Experimental Setup
  - ★ Digital control of pulsed elements
  - ★ Vertical correction coils added to ring sections
  - ★ Control Interface
- Optimization of Injection
- Initial Beam steering through ring
- Beam transport
  - ★ >100 turns at low current (0.7 mA)
  - ★ Multi-turn of 24 mA beam ( $c=0.9$ )

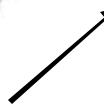
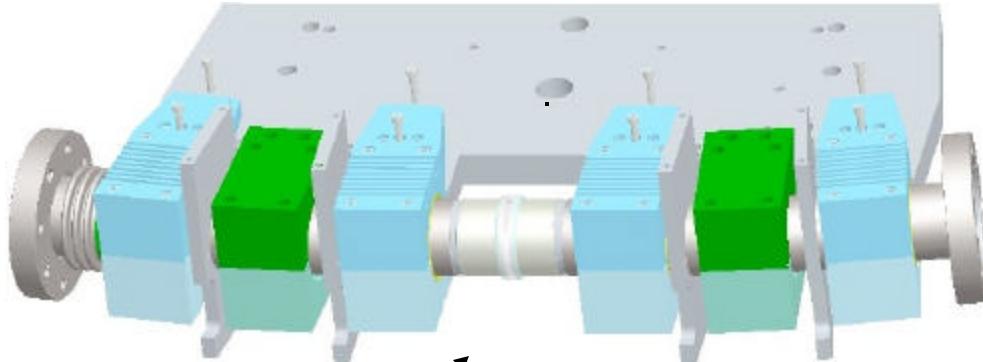


## Future Work

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- Calibration of Steering offset in Quads  
Completion of Response Matrix
- Refinement of return beam path in Y
- Extraction Line construction
- Alignment of  $e^-$  gun and solenoid to Q1

# Induction Gaps



Future – Induction Module for

- Study of longitudinal dynamics
- L/T coupling
- Beam acceleration

Also may be utilized for  
Resistive Wall Position Monitor

# Extraction Line/Diagnostic Chamber

